

SYSTEMATIC ANALYSIS OF *ACANTHOCOCCUS* SPECIES  
(HOMOPTERA: COCCOIDEA; ERIOCOCCIDAE) INFESTING  
*ATRIPLEX* IN WESTERN NORTH AMERICA

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*Abstract.*—Salt bush (*Atriplex* spp.) (Chenopodiaceae) is an important source of forage for livestock at critical times of the year. Salt bush species are declining and suffering dieoff over extensive areas in the Great Basin and on the Colorado Plateau of western North America (Nelson et al. in press). Surveys of potential insect pests of several salt bush species have been conducted and several members of the scale insect genus *Acanthococcus* (= *Eriococcus*) have been discovered. The purpose of this paper is to provide systematic information on the *Acanthococcus* species that occur on *Atriplex* to assist ongoing research on dieoff problems. Included are seven species of which three are new and four are redescribed.

*Key Words:* Scale insect, eriococcid, saltbush

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In the United States, the genus *Acanthococcus* has been treated as a junior synonym of *Eriococcus*. However, the occurrence of distinctive enlarged tubular ducts on the type species of *Eriococcus* (*Coccus buxi* Fonscolombe) which are present on other species from Australia and Europe and are absent from the type species of *Acanthococcus* (*Acanthococcus aceris* Signoret) and most other species from around the world, have convinced me that Borchsenius (1948) was correct when he treated *Acanthococcus* and *Eriococcus* as valid and separate genera. Because of this change, all of the U.S. species previously treated as members of *Eriococcus*, should now be considered as members of *Acanthococcus*.

#### METHODS

Terminology used in this paper follows Miller and McKenzie (1967), Miller and Gonzales (1975), and Miller (1984). When first reading the terminology for the en-

larged setae there may be some confusion. There generally are two distinct sizes of enlarged setae, i.e. large-sized enlarged setae and small-sized enlarged setae. Unfortunately, these sizes are relative within a species; no consistent size criterion can be used to decide whether a seta is large sized or small sized among all species. However, in nearly all cases these relative sizes are distinct and there should be no confusion when studying a particular species or specimen. In one or two cases a species may have setae that intergrade from very large to small, but this circumstance is unusual and is a useful character state. Leg measurements are taken on the outer surface of each segment. Counts of enlarged setae include all enlarged setae on the segment dorsal and ventral. All dorsal setae are considered to be enlarged even though some may be quite small. Measurements and numbers are taken from 10 specimens when available and are given as a

range of numbers followed by the average in parentheses.

Depositories of specimens are as follows: British Museum (Natural History), London (BM); California Department of Food and Agriculture, Sacramento (CDA); University of California, Davis (UCD); University of Hawaii, Honolulu (UH); National Museum of Natural History, Washington, D.C. (USNM); Virginia Polytechnic Institute and State University, Blacksburg (VPI); Zoological Institute, Academy of Sciences of USSR, Leningrad (ZAS). Other abbreviations are: specimen (spm.), slide (sl.), and ad. (adult).

ACKNOWLEDGMENTS

I am grateful to the following individuals for their criticisms and comments of this manuscript: C. Riley Nelson, Department of Zoology, University of Texas, Austin; John A. Davidson, Department of Entomology, University of Maryland, College Park; Robert L. Smiley and Sueo Nakahara, Systematic Entomology Laboratory, ARS, USDA, Beltsville, Maryland. Riley Nelson's suggestions were especially helpful as a potential user of the information provided in the publication.

KEY TO ADULT FEMALES OF  
*ACANTHOCOCCUS* SPECIES THAT INFEST  
*ATRIPLEX*

- 1. Five setae on hind tibia ..... 3  
Four setae on hind tibia ..... 2
- 2(1). Anal lobes each with 4 enlarged setae .....  
..... *froebeae* Miller, n. sp.  
Anal lobes each with 3 enlarged setae .....  
..... *tinsleyi* (Cockerell)
- 3(1). Enlarged setae with round or blunt apices .. 4  
Enlarged setae with acute apices (Fig. 7) ..  
..... *whiteheadi* Miller, n. sp.
- 4(3). Fewer than 65 enlarged setae on segment V  
including those on dorsum and venter ... 5  
More than 65 enlarged setae on segment V  
including those on dorsum and venter ...  
..... *barri* Miller, n. sp.
- 5(3). Enlarged setae not fusiform in shape ..... 6  
Enlarged setae fusiform in shape (Fig. 5) ..  
..... *salaris* (Ferris)
- 6(5). Microtubular ducts without sclerotized ring

at dermal orifice; cruciform pores normally absent ..... *arenosus* (Cockerell)  
Microtubular ducts usually with sclerotized ring at dermal orifice; cruciform pores present ..... *erigoni* (Ehrhorn)

TREATMENT OF SPECIES

*Acanthococcus arenosus* (Cockerell),  
NEW COMBINATION  
Sand eriococcin  
Fig. 1

*Eriococcus arenosus* Cockerell, 1897, 1899, 1900; Fernald, 1903; Ferris 1955; McDaniel, 1959; Hoy, 1963.

*Type material:* From the syntypes I have chosen and marked as lectotype an adult female labeled "*Eriococcus arenosus* Ckll., On ?, N. Mex., Cockerell, April 16, 1897 Type" (USNM). The slide contains only 1 specimen. In addition, there are 4 paralectotypes on 2 slides.

*Field features:* Adult female elongate oval. Body varies from gray to light purple. A smooth, heavy, white ovisac may be intermixed with grains of sand.

This species is found on the spines and branches of its host.

*Recognition characters:* Adult female, mounted, 2.2–3.8 (3.0) mm long, 1.7–2.4 (2.1) mm wide. Anal lobes lightly sclerotized ventrally; each lobe dorsally with 3 enlarged setae (size variable, either lateral seta equal to posteromedial seta, antero-medial seta shortest, or all setae equal in size), with from 1–5 (3) microtubular ducts; each lobe ventrally with 3–4 (3) body setae and 2–9 (4) sessile pores.

DORSUM with enlarged setae of 2 primary sizes: with 2 larger setae along margin of each abdominal segment, also present along thorax and head; remaining setae small. Largest large seta 29–44 (37)  $\mu$  long, largest small seta 19–44 (35)  $\mu$ ; on abdominal segments VIII through III longest large seta 1.2–1.7 (1.5) times longer than longest small seta. All enlarged setae slightly curved; those from northern areas slender, apices rounded; those from southern areas robust,

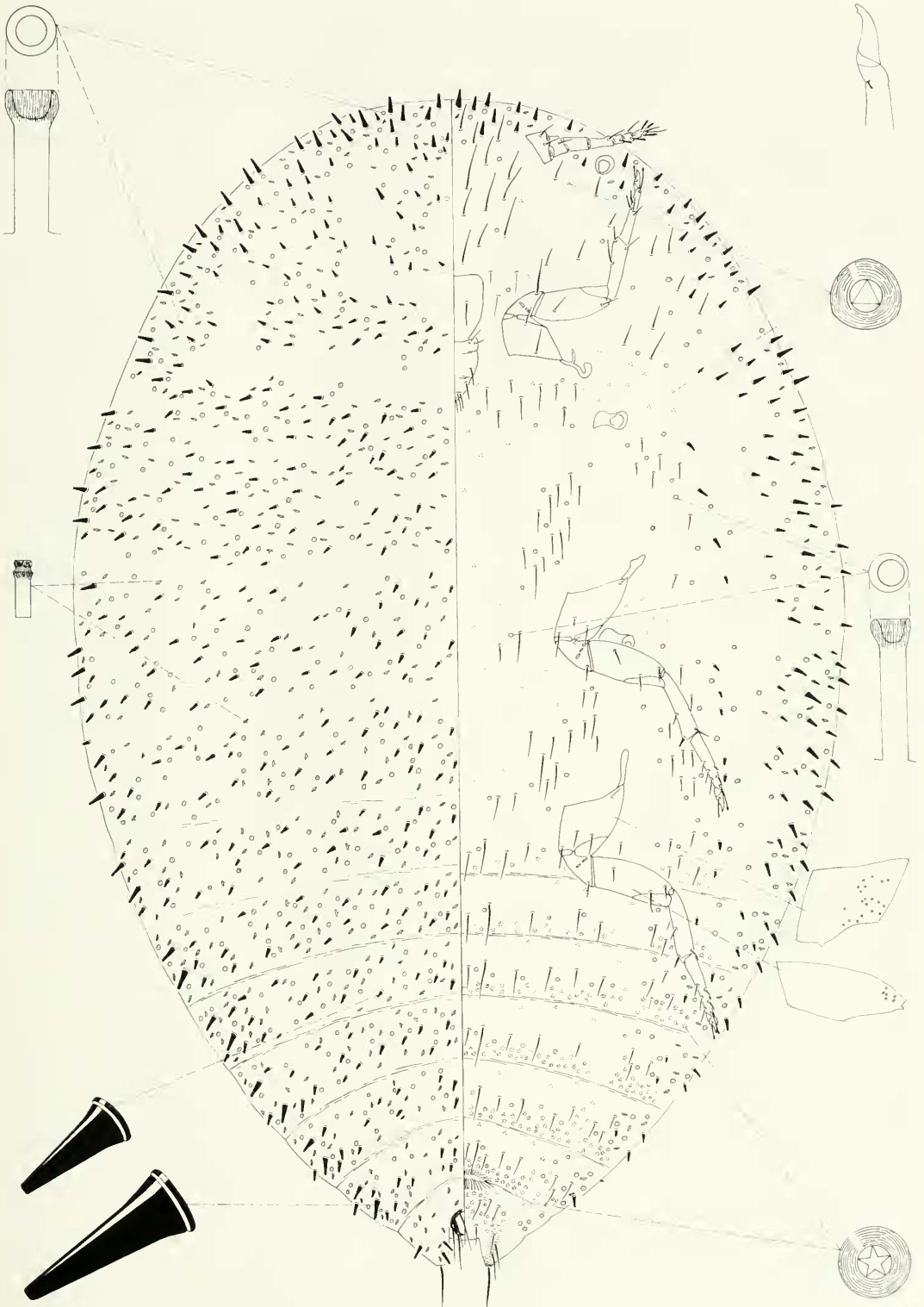


Fig. 1. *Acanthococcus arenosus* (Cockerell). 14 miles W. Phoenix, Arizona, October 15, 1968, on *Atriplex* sp.

apices truncate; all with thin setal rings. Enlarged setae ranging from infrequent to abundant—e.g. abdominal segment V with 22–55 (37)—large setae showing no longitudinal pattern. Macrotubular ducts variable in length (4–8 (6)  $\mu$  long), with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, equal or slightly shorter than remaining sclerotized portion; total sclerotized portion unusually short, varying from 0.5–2.0 (1.0) times length of unsclerotized portion; dermal orifice with no sclerotized ring. Microtubular ducts scattered over surface.

Anal ring either dorsal or ventral, with 4, rarely 5, pairs of setae.

VENTER with lanceolate body setae long (longest seta on abdominal segment VIII from 32–64 (48)  $\mu$  long, on segment III from 53–84 (67)  $\mu$ ), medial setae rarely capitate. Enlarged setae same as on dorsum, except more slender, present along margins of abdominal segment VIII through head. Macrotubular ducts of 2 sizes: larger size on lateral areas only; smaller size on medial and sublateral areas of entire surface, most abundant on abdomen. Microtubular ducts restricted to lateral margins only, uncommon. Multilocular sessile pores of 3 kinds: septeloculars rarely present; quinqueloculars abundant on posterior margins of abdominal segment, rare on anterior margins of abdomen, thorax, and head; triloculars most abundant on thorax and head, also present on anterior margins of abdomen. Cruciform pores usually absent, rarely with a few near lateral margins of anterior abdominal segments, thorax, and head.

Legs: hind coxae dorsally with 4–35 (15) pores, ventral surface with 0–25 (10); hind femora dorsally with 0–7 (3) pores, ventral surface with 0–2 (1); tibiae with 5 setae; inner, apical, tibial setae robust on hind 2 pairs of legs, lanceolate on front pair of legs; hind tarsi usually slightly longer than tibiae (hind tibia/tarsus ratio 0.89–1.06 (0.95)); claws with denticle near tip. Antennae 7-segmented, third or fourth segment lon-

gest. Segment 7 with 3 sensory setae; segment 6 with 1 noticeably longer than single sensory seta on segment 5.

*Notes:* There appear to be two extreme forms of this species, one that occurs in northern Oregon, northern Utah, and northern and central Nevada, and another that occurs in central and southern Nevada, Arizona, New Mexico, and Texas. The northern form is characterized by slender, enlarged setae with rounded apices; whereas, the southern form possesses robust, enlarged setae with truncate apices. Intermediate forms occur in southern Nevada and northern Arizona.

This species is similar to *Acanthococcus eriogoni* (Ehrhorn), but differs in possessing: few or no cruciform pores, microtubular ducts without sclerotized ring orifice; *A. eriogoni*, on the other hand, possesses: many cruciform pores, microtubular ducts usually with heavily sclerotized ring orifice.

*Specimens examined:* ARIZONA, MARICOPA Co.: Phoenix, X-10-1899, on *Atriplex canescens* (Chenopodiaceae), T. D. A. Cockerell (3 spm. on 2 sl.) USNM; 14 mi. W. Phoenix, X-15-68, on *Atriplex* sp., P. F. Min and Miller (2 ad. female on 2 sl.) CDA; Tempe, butte, VIII-(?)–18, on *Atriplex* sp., G. F. Ferris (1 ad. female) UCD.

NEVADA, LYON Co: Weeks, VII-5-68, on *Atriplex* sp., D. R. Miller and R. F. Denno (5 ad. female on 2 sl.) UCD. NYE Co.: Tonopah, VII-6-62, on (?), collector (?) (6 ad. female on 3 sl.) CDA. WASHOE Co.: Nixon, VI-24-64, on *Bassia hyssopifolia* (Chenopodiaceae), J. A. Froebe (1 ad. female) UCD; near Reno, VII-2-47, on *Atriplex* sp., G. F. Ferris (4 ad. female) UCD. WHITE PINE Co.: 3 mi. N. McGill on *Atriplex* sp., D. R. Miller and R. F. Denno (1 ad. female) UCD; 6 mi. NE. McGill, on *Atriplex* sp., D. R. Miller and R. F. Denno (1 ad. female) UCD.

NEW MEXICO, DONA ANA Co.: Las Cruces, date (?), on *A. canescens*, "M. and F." (1 spm.) USNM; VIII-4-66, on *Atriplex* sp., D. R. Miller (3 ad. female on 2 sl.) UCD;



Mesilla Park, VIII-(?)-1898, on *A. canescens*, T. D. A. Cockerell (3 spm. on 2 sl.) USNM. RIO ARRIBA Co.: Embundo, IV-26-1897, on *Psoralea micrantha* (Leguminosae), T. D. A. Cockerell (1 ad. female lectotype, 4 ad. female paralectotypes on 2 sl.) USNM.

OREGON, LAKE Co.: Alkali Lake, VIII-4-68, on *Gutierrezia* sp. (Compositae), D. R. Miller and R. F. Denno (1 ad. female) UCD; 24 mi. E. Christmas Valley, VIII-4-68, on *Atriplex canescens*, D. R. Miller and R. F. Denno (4 ad. female on 2 sl.) UCD; 9 mi. N. Valley Falls, VIII-4-68, on *A. canescens*, D. R. Miller and R. F. Denno (5 ad. female on 3 sl.) UCD.

TEXAS, PRESIDIO Co.: Presidio, XI-19-43, on *A. canescens*, J. H. Russell (4 spm.) USNM; Presidio, IV-29-52, on *A. canescens*, J. H. Russell (5 spm.) USNM.

UTAH, BOX ELDER Co.: 40 mi. SW. Rosette, VIII-2-67, on *Atriplex* sp., D. R. Miller and D. S. Horning (1 ad. female) UCD. KANE Co.: Kanab, III-28-59, on *Sarcobatus vermiculatus* (Chenopodiaceae), G. F. Knowlton (4 ad. female) USNM.

*Hosts and distribution:* Found on *Atriplex*, *Gutierrezia*, *Psoralea*, and *Sarcobatus*. *Acanthococcus arenosus* is the most commonly collected on *Atriplex*.

Distributed in arid areas of Arizona, Nevada, New Mexico, Oregon, Texas, and Utah.

*Acanthococcus barri* Miller,

NEW SPECIES

Barr eriococcin

Fig. 2.

*Type material:* Adult female holotype (1 specimen on slide) with right label "Eriococcus 2 mi. E. Tonopah, Nye Co., NEVADA 7-VII-1968 *Atriplex canescens* D. R. Miller and R. F. Denno 1230"; left label "Eriococcus barri Miller Holotype TYPE" (deposited at UCD). In addition there are 116 paratypes.

*Field features:* The body is white or light yellow; legs are yellowish-brown. The adult

female is heavily coated with many short, squat crystalline rods that give the body a white appearance. One rod on lateral margin of each abdominal segment is longer and broader than the others; these rods are slightly curved posteriorly. The ovisac is noticeably tough and difficult to break open.

This species occurs on the crown and roots of its host.

*Recognition characters:* Adult female holotype, mounted, 1.9 mm long, 1.2 mm wide (paratypes 1.5–3.3 (2.3) mm long, 1.0–2.5 (1.9) mm wide). Anal lobes slightly protruding, rounded, lightly sclerotized; each lobe dorsally with 3 enlarged setae (anteromedial seta longest and most slender, lateral seta shortest and most robust), with 4 microtubular ducts; each lobe ventrally with 4 body setae and 4 sessile pores.

DORSUM with enlarged setae of 3 sizes: 1 larger seta on margin of each abdominal segment, also present on lateral margin of thorax and head; 1 pair of smaller setae present on medial area and sublateral areas of each abdominal segment; remaining setae of intermediate size. Largest large seta 37  $\mu$  long (paratypes 30–38 (35)  $\mu$ ), largest intermediate seta 28  $\mu$  long (paratypes 25–31 (28)  $\mu$ ), largest small seta 16  $\mu$  long (paratypes 13–16 (15)  $\mu$ ); longest large seta 1.3 times longer than longest intermediate sized seta (paratypes 1.2–1.3 (1.2) times); longest large seta 2.3 times longer than longest small seta (paratypes 1.9–2.4 (2.1) times). Large setae extremely broad, with truncate or blunt apices; intermediate setae similar except apices more rounded; small setae relatively slender, with rounded apices; larger and intermediate setae with setal rings so thin as to appear fused to main body of seta; smaller setae with thin, unfused setal rings. Enlarged setae abundant—e.g. abdominal segment V with 113 (paratypes with 69 to 111 (81))—small setae forming 2 pairs of longitudinal lines (medial, sublateral), large setae forming 1 pair of longitudinal lines (lateral). Macrotubular ducts in small numbers over surface. Microtubular ducts elongate

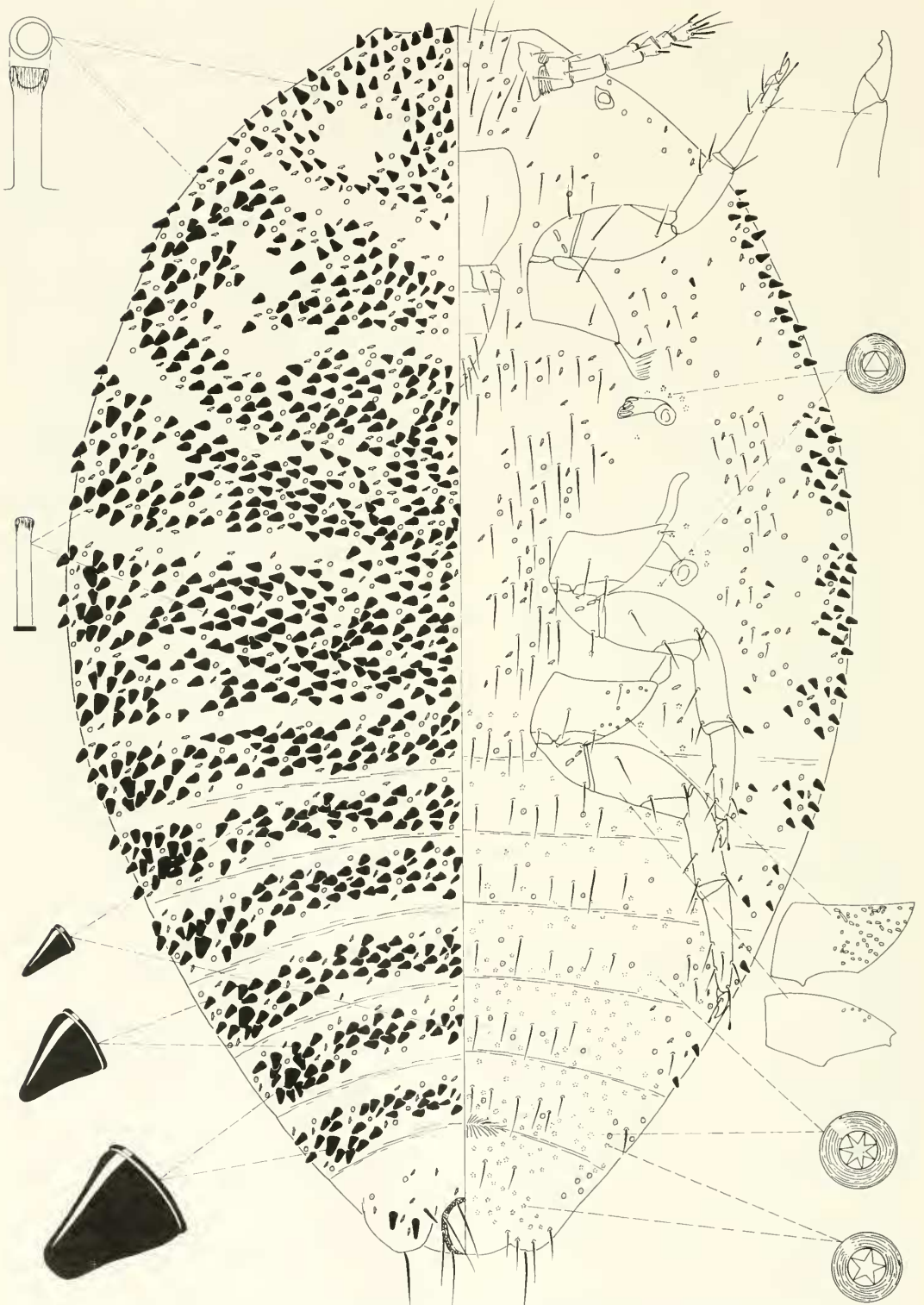


Fig. 2. *Acanthococcus barri* Miller, n. sp. 2 miles E. Tonopah, Nevada, July 7, 1968, on *Atriplex canescens*.

(13  $\mu$  long) (paratypes 11–14 (13  $\mu$ ), with area farthest from dermal orifice sclerotized and undivided; total sclerotized area approximately 0.2 length of unsclerotized area; dermal orifice sclerotized. Microtubular ducts in small numbers over surface.

Anal ring dorsal, with 4 pairs of setae.

VENTER with lanceolate body setae elongate (longest seta on abdominal segment VIII 47  $\mu$  long (paratypes 34–50 (42  $\mu$ ), on segment III 56  $\mu$  (paratypes 47–62 (57  $\mu$ ), medial setae with acute apices. Enlarged setae present along lateral margin from abdominal segment VIII through thorax. Macrotubular ducts same as on dorsum, scattered over surface, most abundant on lateral areas. Microtubular ducts most abundant on lateral areas, also present anterior of each leg. Multilocular sessile pores in unusually small numbers on thorax, and of 3 kinds: septeloculars uncommon, present on posterior abdominal segments; quinqueloculars most abundant, present over abdomen and near spiracles; triloculars uncommon, present on anterior abdominal segments and spiracles. Cruciform pores absent.

Legs: hind coxae dorsally with 45 and 43 pores (paratypes with 27–58 (43)), ventrally with 9 and 30 (paratypes with 18–48 (31)); hind femora dorsally with 6 and 5 (paratypes with 1–7 (5)), ventrally with 0 and 2 (paratypes with 1–6 (4)); tibiae each with 5 setae; inner, apical, tibial setae unenlarged; tarsi slightly longer than tibiae (hind tibia/tarsus ratio 0.88) (paratypes 0.82–0.98 (0.87)); claws with large denticle. Antennae 7-segmented, fourth segment longest. Segment 7 with 3 sensory setae; segment 6 with 1 longer and more slender than single sensory seta on segment 5.

*Variation:* Some of paratypes vary from holotype in possessing the following characteristics: cluster of 6 or 7 small sized setae on dorsum of abdominal segment VIII; anteromedial seta on anal lobes may be unenlarged, appearing as a body seta; 1–4 microtubular ducts on each anal lobe; sessile

pores normally absent on anal lobes; anal ring rarely ventral and with 3 pairs of setae; microtubular duct orifice ring often completely unsclerotized; enlarged setae on venter may be present from abdominal segment VIII through head; antennae rarely 6- or 8-segmented.

*Notes:* I take great pleasure in naming this species *A. barri* in honor of W. F. Barr, University of Idaho. He has provided specimens of this unusual species, and has also contributed many other Coccoidea collections. His assistance has contributed greatly towards a more comprehensive understanding of the scale insects of the northwestern United States.

This species is similar only to *A. whiteheadi* Miller. It differs in possessing: differently shaped dorsal setae, and a different enlarged setal pattern. For detailed discussion see "notes" under *A. whiteheadi*.

*Specimens examined:* IDAHO, CANYON Co.: 15 mi. S. Nampa, VI-27-53, on *Atriplex confertifolia* (Chenopodiaceae), W. F. Barr (3 ad. female paratypes on 3 sl.) UCD, CDA; IX-4-62, on *Atriplex* sp., W. F. Barr (6 ad. female paratypes on 6 sl.) UCD, VPI. ELMORE Co.: 15 mi. W. Mountain Home, VII-31-58, on *Atriplex* sp., W. F. Barr (4 ad. female paratypes on 4 sl.) BM, UCD, UH; IX-3-62, on *Atriplex* sp., W. F. Barr (4 ad. female paratypes on 3 sl.) UCD, ZAS. OWYHEE Co.: 5 mi. N. Murphy, VII-25-56, on *Atriplex* sp., W. F. Barr (2 ad. female paratypes on 2 sl.) UCD.

NEVADA, ESMEERALDA Co.: 6 mi. W. Tonopah, VII-6-68, on *A. canescens*, D. R. Miller and R. F. Denno (7 ad. female paratypes on 5 sl.) UCD, USNM. NYE Co.: 2 mi. E. Tonopah, VII-7-68, on *A. canescens*, D. R. Miller and R. F. Denno (1 ad. female holotype, 32 ad. female paratypes, 26 first instar nymph paratypes, 19 ad. male paratypes, 1 third instar male paratype, 1 fourth instar male paratype on 22 sl.) UCD; 28 mi. NE. Warm Springs, VII-7-68, on *A. canescens*, D. R. Miller and R. F. Denno (4 ad. female paratypes on 2 sl.) UCD.



*Host and distribution:* Found only on *Atriplex*.

Probably occurring throughout much of the Great Basin.

***Acanthococcus eriogoni* (Ehrhorn),**

NEW COMBINATION

*Eriogonum eriococcin*

Fig. 3

*Eriococcus sidae* Ferris, 1955; Hoy, 1963; McDaniel, 1964.

*Eriococcus sidae* Ferris, 1955; Hoy, 1963; McDaniel, 1964.

*Type material:* From the syntypes I have chosen and marked as lectotype an adult female labeled "Eriococcus eriogoni on *Eriogonum*, Flagstaff Arizona Type" (USNM). There are 8 specimens on the slide; the specimen horizontally on the right and vertically in the middle is the lectotype. In addition, there are 7 paralectotypes.

I have examined part of the type series of *E. sidae*.

*Field features:* Adult female oval. Newly formed adult females vary from gray to green; becoming red with age. Crystalline rods numerous over entire dorsum giving eriococcin a wooly appearance.

Present on roots and subterranean or aerial crown of hosts.

*Recognition characters:* Adult female, mounted, 1.7–2.5 (2.2) mm long, 0.9–1.8 (1.2) mm wide. Anal lobes apically acute, moderately sclerotized; each lobe dorsally with 3 enlarged setae (lateral seta either equal to or larger than posteromedial seta, antero-medial seta shortest), with 0–3 (2) microtubular ducts; each lobe ventrally with 3, rarely 4, slender body setae and 2–9 (5) sessile pores.

DORSUM with enlarged setae of 2 primary sizes: 1 seta on margin of each abdominal segment and several on margins of thorax and abdomen large; remaining setae conspicuously smaller. Largest large seta 41–67 (54)  $\mu$  long, largest small seta 33–50 (40)  $\mu$ ; on abdominal segments VIII through III

longest lateral setae, including large type, straight, with apices rounded, slightly more acute than apices of medial seta; medial sublateral setae conspicuously curve, with apices rounded; all with thin setal rings. Enlarged setae abundant—e.g. abdominal segment V with 27–55 (43)—these setae normally showing no longitudinal pattern; although rarely there may be weak indication of 3 pairs of longitudinal lines, these suggested by slightly larger setae, when present, these lines not visible anterior of abdominal segment V. Macrotubular ducts densely scattered over dorsum. Microtubular ducts moderate in length 6–8 (7)  $\mu$  long, with area farthest from dermal orifice sclerotized and weakly divided into 2 parts, apical portion rounded, from 0.5–1.0 (0.8) times length of remaining sclerotized portion; total sclerotized area varying from 1–5 (2) times longer than unsclerotized area; dermal orifice varying from heavily sclerotized to totally unsclerotized. Microtubular ducts abundant over surface.

Anal ring ventral, rarely dorsal, with 3, normally 4, pairs of setae.

VENTER with lanceolate body setae moderate in length (longest seta on abdominal segment VIII from 39–50 (45)  $\mu$  long, on segment III from 47–62 (55)  $\mu$ ), medial setae stout, capitate. Enlarged setae normally of small size, straight; present near body margin from abdominal segment VIII through head. Macrotubular ducts of 2 kinds: larger size present on lateral and sublateral areas; smaller size normally only slightly smaller than large size, present in medial areas from segment VII or VI through head. Microtubular ducts present over entire surface, most abundant near lateral margins. Multilocular sessile pores of 3 kinds: septeloculars least common, if present, usually on abdominal segment IX or VIII; quinqueloculars most abundant, present over entire surface; triloculars present on anterior abdominal segments, thorax, and head. Cruciform pores present along lateral margin of anterior abdominal segments, on



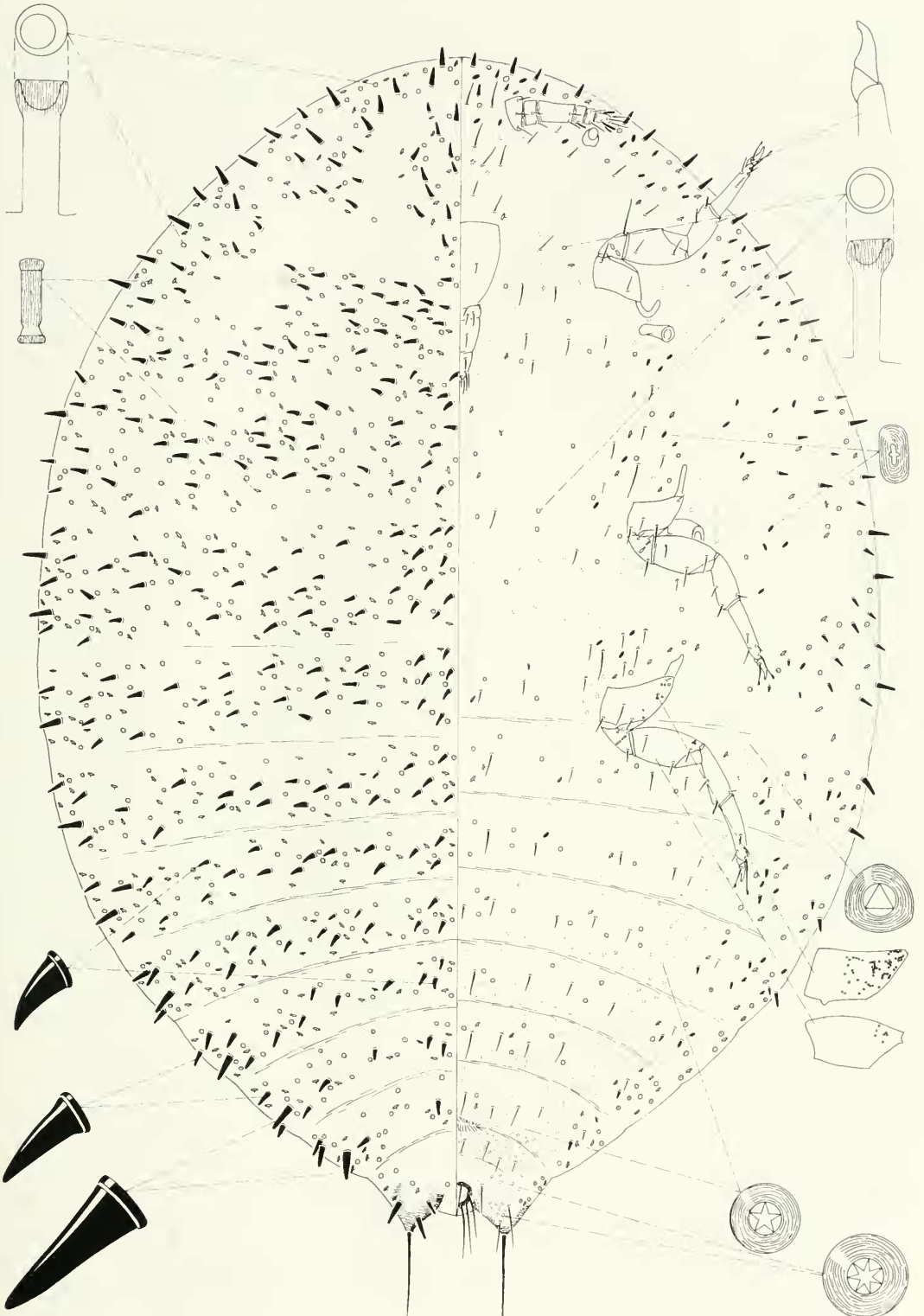


Fig. 3. *Acanthococcus eriogoni* (Ehrhorn). Flagstaff, Arizona, date and host unknown.

lateral areas of thorax and head, and anterior of each leg.

Legs: hind coxae dorsally with 17–45 (27) pores, ventral surface with 4–20 (12); hind femora dorsally with 3–14 (8) pores, ventral surface with 0–5 (2); tibiae with 5 setae; inner, apical, tibial setae robust; tarsi longer than tibiae (hind tibia/tarsus ratio 0.78–0.93 (0.88)); claws with denticle near tip. Antennae 6-segmented, rarely with third segment divided forming seventh segment, third segment longest. Apical segment with 2 or 3 sensory setae; second segment from apex with sensory setae absent; third segment from apex with only 1 which is short and robust.

*Notes:* This is an extremely variable species. I believed for some time that it was a synonym of *A. dubius*, but after careful consideration, I have concluded that they are distinct. Because of the extreme variability within these species, it is not possible to use one character to separate them, instead, it is necessary to use a combination of characters. *Acanthococcus eriogoni* possesses: enlarged setae with rounded apices; strongly curved medial and sublateral setae; medial and sublateral setae all of approximately the same size, particularly on abdominal segment V forward through head; front tibiae with 5 setae; and microtubular ducts with long area of sclerotization; *A. dubius*, on the other hand, possesses: enlarged setae with acute apices; straight or slightly curved medial and sublateral setae; medial and sublateral setae of 2 sizes, large size forming 3 pairs of longitudinal lines from abdominal segment VIII through posterior thorax; front tibiae normally with 6 setae; and microtubular ducts normally with short area of sclerotization.

See "notes" under *E. arenosus* for an additional comparison.

*Specimens examined:* ARIZONA, COCHISE Co.: 21 mi. N. Bisbee, VIII-2-66, on (?), D. R. Miller (1 ad. female) UCD. COCONINO Co.: Flagstaff, date (?), on (?),

O. E. Bremner (4 ad. female of 4 sl.) CDA, UCD; on *Eriogonum* sp. (Polygonaceae), collector (?) (1 lectotype ad. female and 7 paralectotypes on 1 sl.) USNM; IX-(?)-1900, on *Eriogonum* sp., O. E. Bremner (5 ad. female on 4 sl.) UCD; Yuba City, on *Haplopappus acradenius* (?) (Compositae), H. L. McKenzie (4 ad. female on 3 sl.) UCD. MARICOPA Co.: quarantined at Phoenix from Alamo, Texas, I-21-69, on *Echinopsis* sp. (Cactaceae), P. F. Min and Hancock (2 ad. female on 2 sl.) UCD, CDA; 5 mi. E. Phoenix, IX-3-68, on (?) (Chenopodiaceae), D. R. Miller and J. E. Lauck (2 ad. female) UCD. PIMA Co.: 35 mi. S. Tucson, Santa Rita Range, on *Eriogonum wrightii*, H. S. Haskell (17 ad. female, 7 second instar female, 65 first instars, 3 second instar male on 6 sl.) UCD.

CALIFORNIA, IMPERIAL Co.: 1 mi. W. Glamis, I-28-65, on *Eriogonum* sp., D. R. Miller (2 ad. female on 2 sl.) UCD; 12 mi. E. Holtville, XII-11-58, on *Ephedra californica* (Ephedraceae), G. L. Osborn (12 ad. female, 5 second instar female, 3 first instar, 1 ad. male, 1 fourth instar male, 3 second instar male on 7 sl.) CDA, UCD; Imperial, XII-28-63, on "cactus," L. Phipps and G. Skaggs (3 ad. female on 3 sl.) CDA. LOS ANGELES Co.: Lancaster, VI-12-18, on *Haplopappus* (= *Isocoma*) *venetus*, G. F. Ferris (6 ad. female on 2 sl.) UCD. RIVERSIDE Co.: 18 mi. W. Blythe, I-29-65, on *Palafoxia linearis* (Compositae) and *Atriplex* sp. (Chenopodiaceae), D. R. Miller (4 ad. female on 4 sl.) UCD; 4 mi. W. Desert Center, II-20-58, "in soil," E. I. Schlinger (3 ad. female) UCD; Desert Center, IV-18-66, on *Euphorbia* sp. (Euphorbiaceae), R. J. Gill and L. L. Johnson (1 ad. female) CDA; X-5-66, on *Eriogonum deflexum*, D. Fiskaali (1 ad. female, 3 second instar female, 3 second instar male on 6 sl.) CDA. SAN BERNARDINO Co.: 5 mi. S. Kramer Junction, XII-28-64, I-24-65, on *Ceratoides lanata* (Chenopodiaceae), D. R. and J. F. Miller (3 ad. female on 2 sl.) UCD. SAN DIEGO

Co.: Borrego Springs, I-27-65, on *Eriogonum inflatum*, D. R. Miller (2 ad. female on 2 sl.) UCD. SISKIYOU Co.: 7 mi. S. Yreka, VII-20-66, on *Gutierrezia* sp. (Compositae), D. R. Miller (1 ad. female) UCD. TULARE Co.: above Mineral King, date (?), on *Eriogonum* sp., G. F. Ferris (2 ad. female) UCD.

FLORIDA, COUNTY (?): Fruit Cove, VII-27-66, on (?) (Cactaceae), A. E. Graham (2 ad. female on 2 sl.) CDA.

NEVADA, LYON Co.: 5 mi. S. Wabuska, VII-5-68, *Ceratoides lanata*, D. R. Miller and R. F. Denno (4 ad. female on 2 sl.) UCD. WASHOE Co.: Reno, I-2-59, on "cactus," R. F. Rebuffo (6 ad. female on 3 sl.) CDA.

TEXAS, BAILEY Co.: Muleshoe, (?)-(?)-21, on *Meriolix serrulata* (Onagraceae), G. F. Ferris (5 ad. female on 3 sl.) UCD. BREWSTER Co.: Chisos Mountains, (?)-(?)-21, on *Paronychia jamesii* (Caryophyllaceae), G. F. Ferris (4 ad. female on 3 sl.) UCD. EL PASO Co.: near El Paso, date (?), on *Sida hederiae* (Malvaceae), collector (?) (12 ad. female on 7 sl.) UCD. PECOS Co.: near Sheffield, Pecos River, (?)-(?)-21, on *Croton* sp. (Euphorbiaceae), G. F. Ferris (3 ad. female on 3 sl.) UCD.

*Host and distribution:* Found on many plant genera: *Atriplex*, *Croton*, *Echinopsis*, *Ephedra*, *Eriogonum*, *Euphorbia*, *Eurotia*, *Gutierrezia*, *Haplopappus*, *Meriolix*, *Palafoxia*, *Paronychia*, and *Sida*. There seems to be no particular host pattern.

Distributed in warm areas of southwestern United States.

### *Acanthococcus froebeae* Miller,

#### NEW SPECIES

Froebe eriococcin

Fig. 4

*Type material:* Adult female holotype (1 specimen on slide), left label "Eriococcus froebeae Miller TYPE"; right label "5 mi. n. Baker, San Bernardino Co. Calif., on *Franseria* sp. IV-13-63, D. R. Miller"

(UCD). In addition there are 2 paratypes (UCD).

*Field features:* This species occurs on the foliage of its host.

*Recognition characters:* Adult female holotype, mounted 2.2 mm long, 1.4 mm wide (paratypes 2.1–2.7 (2.4) mm long, 1.5–1.8 (1.7) mm wide). Anal lobes slightly protruding, acute, slightly sclerotized; each lobe dorsally with 4 enlarged setae (anterolateral seta smallest, remaining 3 setae approximately equal), with 4 or 5 microtubular ducts; each lobe ventrally with 3 body setae and 1 sessile pore.

DORSUM with setae of 1 size; largest seta 31  $\mu$  long (paratypes 34–35 (35)  $\mu$ ), smallest seta 16  $\mu$  long (paratypes 18–19 (18)  $\mu$ ); longest seta 2.0 times longer than smallest seta (paratypes 1.8–1.9 (1.9) times). All setae slightly curved, slender, with rounded apices; setal rings thin. Enlarged setae abundant—e.g. abdominal segment V with 60 (paratypes 52–78 (62))—with no longitudinal pattern. Macrotubular ducts scattered over surface. Microtubular ducts moderate in length (6  $\mu$  long) (paratypes 5–6 (6)  $\mu$ ), with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion small, approximately 0.2 times length of remaining sclerotized portion; total sclerotized area shorter than unsclerotized area; dermal orifice only weakly sclerotized. Microtubular ducts numerous over surface.

Anal ring bent around abdomen apex, with 4 pairs of setae.

VENTER with lanceolate body setae moderate in length (longest seta on abdominal segment VIII 37  $\mu$  long (paratypes 41–44 (43)), on segment III 44  $\mu$  (paratypes 56–62 (58)  $\mu$ ), medial setae with apices acute. Enlarged setae present along lateral margin from abdominal segment VIII through head. Macrotubular ducts of 2 kinds: larger size same as on dorsum, present along lateral margins and on medial and sublateral areas of thorax and head; smaller size present on

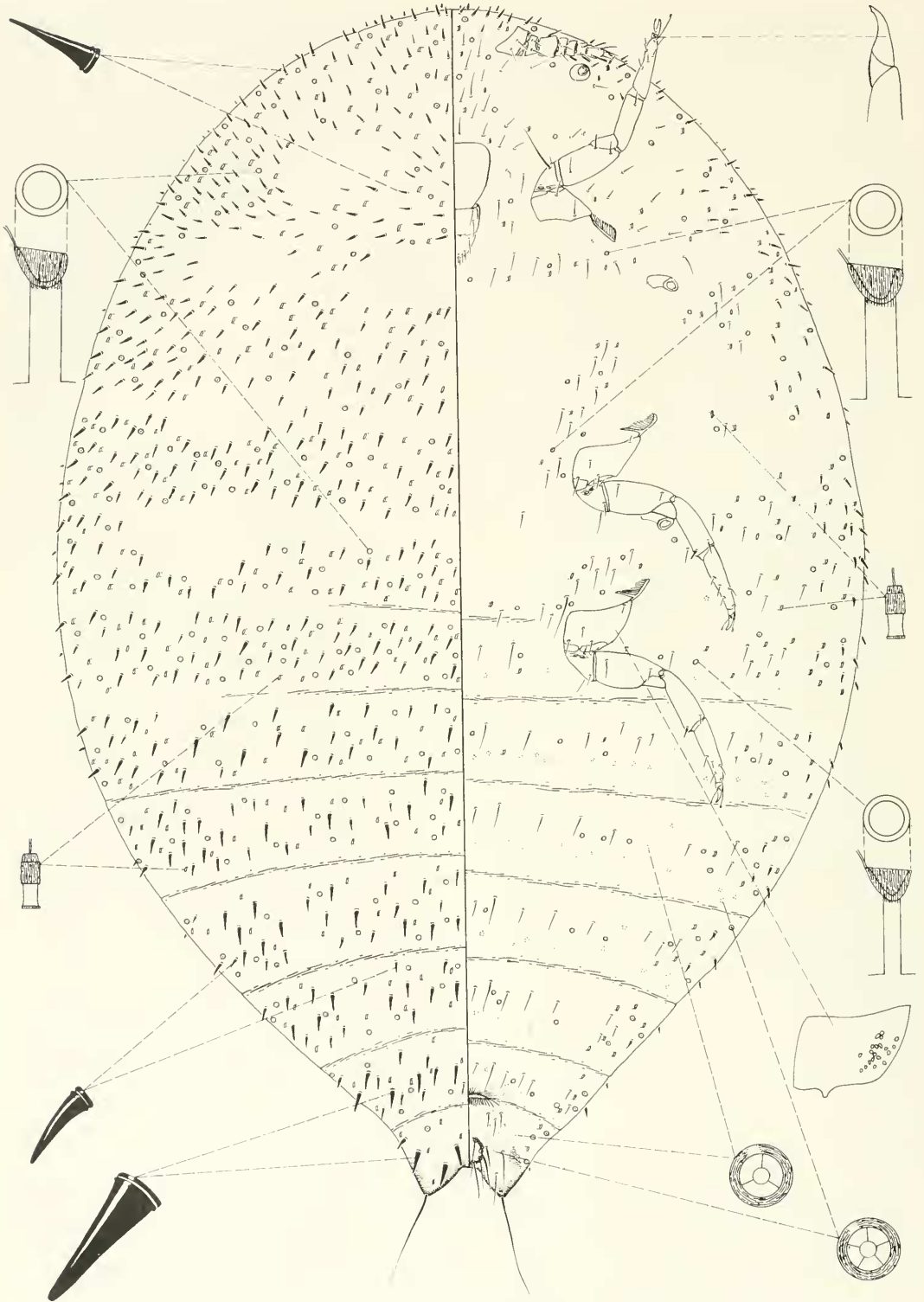


Fig. 4. *Acanthococcus froebeae* Miller. 5 miles N. Baker, California, April 13, 1963, on *Franseria* sp.



medial and sublateral areas of abdomen. Microtubular ducts most abundant along lateral margins, also present on medial areas of anterior abdominal segments, thorax, and head. Multilocular pores of 2 kinds: quinqueloculars present over entire surface except thorax; triloculars rare. Cruciform pores absent.

Legs: hind coxae dorsally with 20 and 25 pores (paratypes with 6–17 (12)), absent on ventral surface; hind femora dorsally with 4 and 6 pores (paratypes with 2–5 (4)), absent on ventral surface; tibiae with 4 setae; inner, apical, tibial setae robust, tarsi slightly longer than tibiae (hind tibia/tarsus ratio 0.90) (paratypes 0.85–1.00 (0.9)); claws with small denticle near tip. Antennae 7-segmented, third segment longest. Segment 7 with 3 slender sensory setae; segment 6 with 1 slightly longer and more slender than single sensory seta on segment 5.

*Variation:* The paratypes agree well with holotype.

*Notes:* I take great pleasure in naming this species *A. froebeae* in honor of Judith Froebe Miller, my wife, who has helped me collect scale insects for more than 30 years, including this species. She has been especially tolerant and supportive of my obsession for Coccoidea systematics and for that I am eternally grateful.

This species is distinct in possessing the following combination of characters: 4 setae on each tibia; enlarged seta of essentially 1 size scattered over entire dorsum; 4 enlarged setae on each anal lobe.

*Specimens examined:* CALIFORNIA, RIVERSIDE Co.: 7 mi. N. Indio, III-26-64, on *Atriplex* sp. (Chenopodiaceae), D. R. Miller and J. A. Froebe (2 ad. female paratype) USNM; 11 mi. N. Indio, VIII-24-68, on *Atriplex* sp., D. R. Miller (1 ad. female paratype) UCD. SAN BERNARDINO Co.: 5 mi. N. Baker, IV-13-63, on *Franseria* sp. (Compositae), D. R. Miller (1 ad. female holotype) UCD.

*Host and distribution:* Known on *Atriplex* and *Franseria*.

Probably occurs throughout warm area of southwestern United States.

*Acanthococcus salarius* (Ferris),

NEW COMBINATION

Salt eriococcin

Fig. 5

*Eriococcus salarius* Ferris, 1955; Hoy, 1963.

*Type material:* I have examined the holotype which is labeled "Eriococcus salarius n. sp. On Atriplex TYPE Salt Dale, near Mojave, Calif. Apr. 26, 1936 G. F. F. Stanford University Natural History Museum" (UCD). In addition I have seen 8 paratypes (UCD, USNM).

*Field features:* Adult females rotund, purple. No ovisac has been observed.

This species is found on the roots of its host.

*Recognition characters:* Adult females, mounted, 2.1–3.1 (2.6) mm long, 1.5–2.6 (2.0) mm wide. Anal lobes rounded, not protruding, lightly sclerotized; each lobe dorsally with 3 enlarged setae (relative sizes variable), with 2 or 3 microtubular ducts; each lobe ventrally with 2 or 3 body setae and from 3–9 (6) sessile pores.

DORSUM with enlarged setae of 2 primary sizes: 1 larger seta on margin of each abdominal segment, also present along margin of thorax and head; remaining setae small. Largest large seta 34–42 (37)  $\mu$  long, largest small seta 10–30 (24)  $\mu$ ; on abdominal segments VIII through III largest large seta 1.3–1.7 (1.5) times longer than longest small seta. All enlarged setae straight, fusiform, apices rounded to blunt; setal ring broad. Enlarged setae abundant—e.g. abdominal segment V with 39–54 (47)—large setae showing no longitudinal pattern. Macroducts moderate in size, scattered over surface. Microtubular ducts moderate in length 6–7 (7)  $\mu$  long, with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, from 0.5–0.8 (0.6) times length of remaining

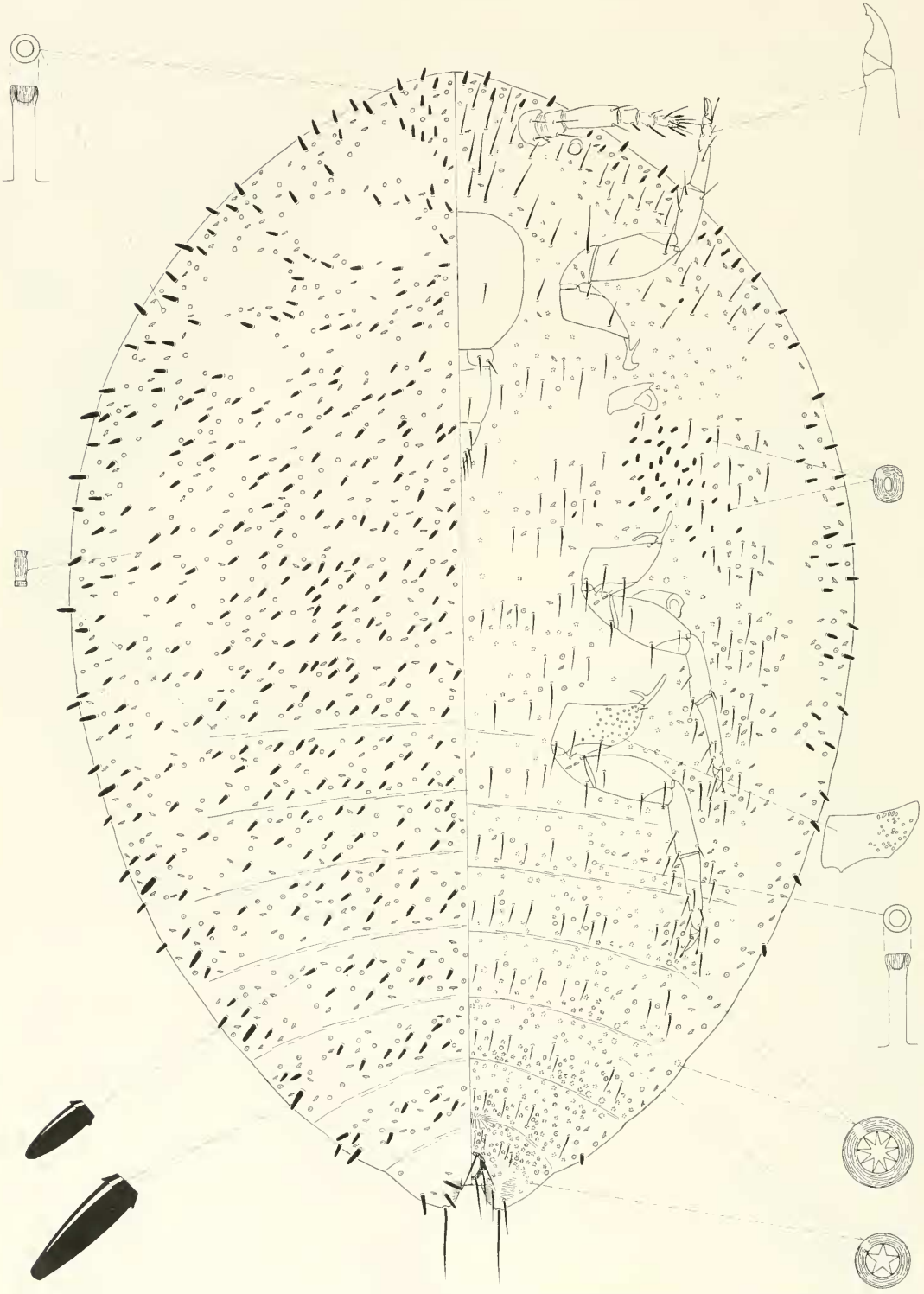


Fig. 5. *Acanthococcus salarius* (Ferris). 15 miles N. Kramer Junction, California, December 27, 1964, on *Atriplex* sp.

sclerotized portion, approximately 4 times length of unsclerotized portion; dermal orifice sclerotized. Microtubular ducts numerous over surface.

Anal ring normally ventral, with 4 or 5 pairs of setae.

**VENTER** with lanceolate body setae elongate (longest seta on abdominal segment VIII from 50–59 (57)  $\mu$  long, on segment III from 53–69 (63)  $\mu$ ), medial setae apically acute. Enlarged setae of small type only, present along margin of abdominal segment VIII through head. Macrotubular ducts of 2 kinds: larger size present on lateral areas of abdomen and scattered over thorax and head; smaller size present on medial and sublateral areas of abdomen near transverse row of body setae. Microtubular ducts on lateral areas of abdomen and scattered over thorax and head. Multilocular sessile pores of 3 kinds: noveloculars and septeloculars scattered in small numbers over entire surface; quinqueloculars abundant. Cruciform pores present only in large clusters below each anterior spiracle.

Legs: hind coxae dorsally with 30–55 (42) pores, ventral surface with 22–47 (38); these pores absent on femora; tibiae with 5 setae; inner, apical tibial setae unenlarged; hind tarsi longer than tibiae (hind tibia/tarsus ratio 0.89–0.97 (0.92)); claws with small denticle near tip. Antennae 6- or 7-segmented, third segment longest. Apical segment with 2 or 3 sensory setae; second segment from apex with 1 slightly longer and more slender than single sensory seta on third segment from apex.

*Notes:* This species is distinct from all other species in the United States in possessing: fusiform enlarged setae and characteristic pattern of cruciform pores.

*Specimens examined:* CALIFORNIA, LOS ANGELES Co.: near Mojave, Salt Dale, IV-26-36, on *Atriplex* sp. (Chenopodiaceae), G. F. Ferris and P. C. Ting (1 ad. female holotype on 1 sl., 8 ad. female paratypes, 1 first instar nymph on 4 sl.) UCD, USNM. SAN BERNARDINO Co.: 15 mi.

N. Kramer Junction, XII-28-64, on *Atriplex* sp., D. R. Miller (3 ad. female on 3 sl.) UCD.

*Host and distribution:* Known only from *Atriplex* on the high deserts of southern California.

*Acanthococcus tinsleyi* (Cockerell),

NEW COMBINATION

Tinsley eriococcin

Fig. 6

*Eriococcus tinsleyi* Cockerell, 1898, 1898a; Tinsley, 1898, Cockerell, 1899, 1900; Fernald, 1903; Cockerell, 1906; Cockerell and Robinson, 1914; Ferris, 1919, 1921; Lobdell, 1929, Ferris, 1955; Hoy, 1963; McDaniel, 1964.

*Nidularia tinsleyi*, Lindinger, 1933.

From the published records of this species the following specimens have been examined and are considered misidentifications: NEW MEXICO, DONA ANA Co.: Mesilla Park, VIII-(?)-1898, on *Atriplex canescens* (Chenopodiaceae), T. D. A. Cockerell (see *E. arenosus*). TEXAS, BAILEY Co.: Muleshoe, (?)-(?)-21, on *Meriolix serrulata* (Onagraceae), G. F. Ferris (see *E. eriogoni*). BREWSTER Co.: Chisos Mountains, (?)-(?)-21, on *Paronychia jamesii* (Caryophyllaceae), G. F. Ferris (see *E. eriogoni*). PECOS Co.: near Sheffield, Pecos River, (?)-(?)-21, on *Croton* sp. (Euphorbiaceae), G. F. Ferris (see *E. eriogoni*).

*Type material:* I have chosen from the syntypes and marked as lectotype 1 of 2 adult females mounted on a slide labeled "Eriococcus tinsleyi Ckll., On roots of *Atriplex canescens* Mesilla Park N. M. April 30 1898 (J. D. Tinsley)" (USNM). The specimen nearest the old label on the right side of the slide is the lectotype. In addition there are 3 lectoparatypes on 1 slide (USNM).

*Field features:* Female broadly oval. Body pale brown to light purple with trace of two longitudinal purple lines dorsally; legs light brown. Covered with many crystalline rods. Ovisac yellowish-white, enclosing adult female and many yellow eggs.





Found on crown and roots of host.

*Recognition characters:* Adult female, mounted, 1.3–1.4 (1.3) mm long, 0.7–0.8 (0.7) mm wide. Anal lobes apically acute, protruding, unsclerotized; each lobe dorsally with 3 enlarged setae (lateral and posteromedial setae equal, anteromedial seta shortest), with 2 or 3 microtubular ducts; each lobe ventrally with 3 or 4 body setae and from 1 to 3 sessile pores.

DORSUM with enlarged setae of 1 primary size with 1 seta on margin of each abdominal segment slightly longer than remaining setae. Largest seta varying from 44–47 (45)  $\mu$  long, smallest seta varying from 25–28 (27)  $\mu$ ; on abdominal segments VIII through III largest seta from 1.6–1.7 (1.6) times longer than smallest seta. All enlarged setae slightly curved, apices rounded; setal rings thin. Enlarged setae abundant—e.g. abdominal segment V with 44–56 (50)—large type setae showing no longitudinal pattern; enlarged setae distributed in characteristic pattern. Macrotubular ducts scattered over dorsum. Microtubular ducts long (8–10 (9)  $\mu$  long), with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, from 0.3–0.5 (0.5) times length of remaining sclerotized portion; total sclerotized portion slightly longer than length of unsclerotized portion; dermal orifice unsclerotized. Microtubular ducts scattered over surface.

Anal ring apical or ventral, with 3 or 4 pairs of setae.

VENTER with lanceolate body setae moderate in length (longest seta on abdominal segment VIII from 22–36 (29)  $\mu$  long, on segment III from 28–41 (37)  $\mu$ ), medial setae apically capitate. Enlarged setae present along margin from abdominal segment VIII or VII through head. Macrotubular ducts of 2 kinds: larger size present on lateral areas; smaller size present on medial and sublateral areas. Microtubular ducts on lateral areas of abdomen, scattered over thorax and head. Multilocular pores of 3 kinds: septeloculars rare or absent; quin-

queloculars scattered over entire surface; triloculars most numerous on thorax. Cruciform pores present on lateral areas from anterior abdominal segments forward to head, a few such pores anterior of mesothoracic pair of legs.

Legs: hind coxae dorsally with 9–25 (12) pores, ventral surface with 5–10 (7); hind femora dorsally with 4–6 (5) pores, absent ventrally; tibiae with 4 setae; inner, apical, tibial setae slightly larger than remaining leg setae; hind tarsi longer than tibiae (hind tibia/tarsus ratio 0.78–0.83 (0.80)); claws with conspicuous denticle near tip. Antennae 6- or 7-segmented, when 7-segmented, segment 4 longest. Apical segment with 3 sensory setae; second segment from apex with 1 longer and more slender than single sensory seta on third segment from apex.

*Notes:* This species is quite similar to *A. eriogoni* (Ehrhorn), but differs in possessing: characteristic dorsal setal pattern, differently shaped microtubular ducts and 4 setae on each tibia; *A. eriogoni*, on the other hand, possesses: 5 setae on each tibia.

*Specimens examined:* ARIZONA, APACHE Co: Springerville, VII-4-18, on *Atriplex canescens* (Chenopodiaceae), G. F. Ferris (2 ad. female) UCD.

CALIFORNIA, RIVERSIDE Co: 11 mi. N. Indio, VIII-24-68, on *Atriplex* sp., D. R. Miller (3 ad. female) UCD.

IDAHO, POWER Co.: 5 mi. S. American Falls, VIII-19-64, on *Chrysothamnus* sp. (Compositae), D. R. and J. F. Miller (4 ad. female on 2 sl.) UCD.

NEW MEXICO, quarantined at Blythe, California, X-25-60, on *Atriplex* sp., D. R. Dilley (3 ad. female on 2 sl.) CDA. DONA ANA Co.: Mesilla Park, X-9-1896, on *Atriplex* sp., Townsend (3 ad. female) USNM; IV-30-1898, on *A. canescens*, J. D. Tinsley (lectotype, 3 paralectotypes on 2 sl.) USNM; X-13-1898, on *A. canescens*, J. D. Tinsley (20 spm. on 2 sl.) USNM.

TEXAS, EL PASO Co.: near Fabens, VIII-(?) -21, on *Atriplex* sp., G. F. Ferris (1 ad. female) UCD.

*Host and distribution:* Known on *Atriplex* and *Chrysothamnus*.

Probably occurring throughout the warm areas of the western United States.

*Acanthococcus whiteheadi* Miller,

NEW SPECIES

Whitehead eriococcin

Fig. 7

*Type material:* Adult female holotype (1 specimen on slide) with left label "Eriococcus whiteheadi Miller TYPE"; right label "8 mi. E. Hawthorne, Mineral Co., NEVADA 6-VII-1968 ex *Atriplex* sp. D. R. Miller & R. F. Denno 1212" (UCD). In addition there is a single paratype.

*Field features:* This is a very unusual eriococcin. In appearance it resembles a fuzzy seed. The body is dark green and is covered ventrally by a light white secretion. Many slender, waxy, crystalline rods are produced from the dorsum giving the body a seed-like appearance.

This species is found on the main roots of its host.

*Recognition characters:* Adult female holotype, mounted, 2.0 mm long, 1.2 mm wide (paratype 2.0 mm long, 1.1 mm wide). Anal lobes strongly protruding, acute, slightly sclerotized; each lobe dorsally with 3 enlarged setae (lateral and posteromedial setae approximately equal, anteromedial seta shortest and most slender), with 3 microtubular ducts; each lobe ventrally with 4 body setae and 4 or 5 sessile pores.

DORSUM with enlarged setae of 2 sizes: larger setae present medially, sublaterally, and laterally, from abdominal segment VIII through thorax, with 2-4 (3) such setae in medial cluster in each abdominal segment, 1 or 2 on sublateral area, and 2 or 3 on each margin; remaining setae of small size. Largest large seta 50  $\mu$  long (paratype 58  $\mu$ ), largest small seta 37  $\mu$  long (paratype 41  $\mu$ ); longest large seta 1.3 times longer than longest small seta (paratype 1.4 times). All setae straight, conspicuously broad basally, with acute apices; setal rings thin, often ap-

pearing fused to remainder of seta. Enlarged setae abundant—e.g. abdominal segment V with 59 (paratype with 69)—large setae forming 5 longitudinal lines (1 medially, 2 sublaterally, and 2 laterally). Macrotubular ducts in small numbers over surface. Microtubular ducts elongate (12  $\mu$  long) (paratype 14  $\mu$ ), with area farthest from dermal orifice sclerotized and weakly divided into 2 parts, apical portion rounded apically, approximately 0.3 times length of remaining sclerotized portion; total sclerotized area approximately 0.3 times length of unsclerotized portion; dermal ring weakly sclerotized, thin, although similar to bifurcate orifice of other species in the genus such as *A. azaleae*, apparently with single opening only. Microtubular ducts in small numbers over surface.

Anal ring bent around abdominal apex, with 4 setae.

VENTER with lanceolate body setae moderate to elongate (longest seta on abdominal segment VIII 50  $\mu$  long (paratype 62  $\mu$ ), on segment III 51  $\mu$  (paratype 63  $\mu$ )), medial setae with capitate apices. Enlarged setae present along lateral margin from abdominal segment VIII through head. Macrotubular ducts of 2 kinds: larger size restricted to lateral areas; smaller size present on medial and sublateral areas near body setae. Microtubular ducts most abundant along lateral margins, also present in small numbers on medial and sublateral areas of thorax and head. Multilocular sessile pores in unusually small numbers on thorax; sessile pores of 2 kinds: quinqueloculars present over entire surface, most abundant on posterior abdominal segments; triloculars present near spiracles and on anterior abdominal segments. Cruciform pores present on sublateral areas of anterior abdominal segments, and on thorax, and head.

Legs: hind coxae dorsally with 22 and 26 pores (paratype with 21 and 26), ventrally with 18 and 23 (paratype with 31 and 23); hind femora dorsally with 2 and 1 pores (paratype with 3 and 5), ventrally with 3

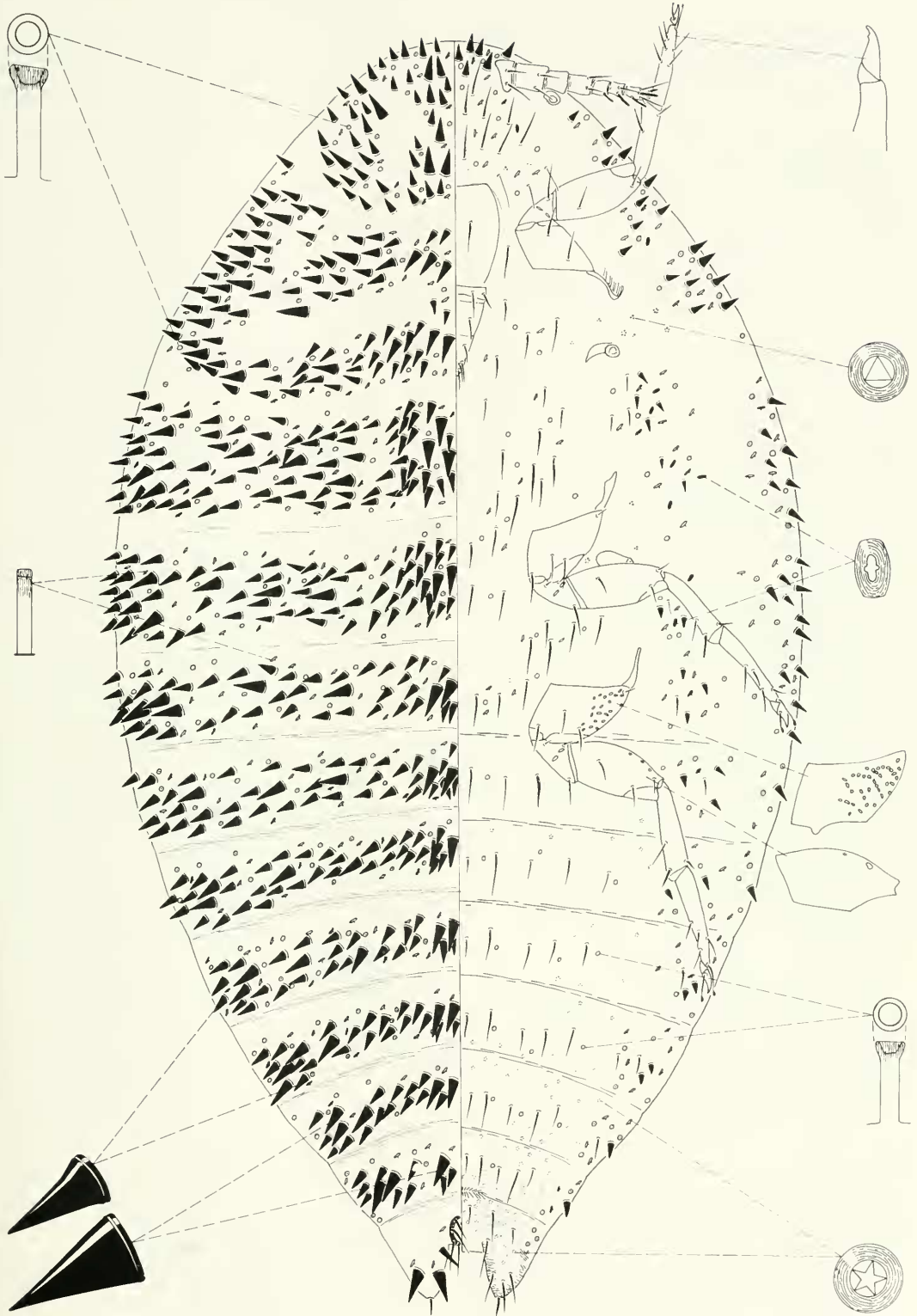


Fig. 7. *Acanthococcus whiteheadi* Miller, n. sp. 8 miles E. Hawthorne, Nevada, July 6, 1968, on *Atriplex* sp.



and 2 (paratype with 2 and 3); tibiae with 5 setae; inner, apical, tibial setae robust; tarsi slightly longer than tibiae (hind tibia/tarsus ratio 0.87) (paratype 0.90); claws with small denticle near tip. Antennae 7-segmented, third segment longest. Segment 7 with 3 sensory setae; segment 6 with 1 longer and more slender than single sensory seta on segment 5.

*Variation:* The paratype agrees with the holotype in nearly all respects except it possesses one 6-segmented antenna.

*Notes:* I take great pleasure in naming this species *A. whiteheadi* in honor of the late Donald R. Whitehead, Systematic Entomology Laboratory, ARS, USDA. He was a good friend who had significant impact on my career. See appendix I for a eulogy that I presented during the memorial service in his honor.

The unusual elongate microtubular ducts are more similar to the microtubulars on species from New Zealand or Australia than to the microtubulars of North American species.

*Specimens examined:* NEVADA, MINERAL Co.: 8 mi. E. Hawthorne, VII-6-68, on *Atriplex* sp. (Chenopodiaceae), D. R. Miller and R. F. Denno (1 ad. female holotype, 1 ad. female paratype on 2 sl.) UCD.

*Host and distribution:* Probably occurring throughout warm areas of the southwestern United States on *Atriplex*.

#### CONCLUSIONS

There are seven species of *Acanthococcus* that feed on *Atriplex* in western North America. This host has more species of *Acanthococcus* than any other plant genus in the region. The genus *Eriogonum* has five species and *Artemisia*, *Gutierrezia*, and *Euphorbia* each have four (Miller 1969). It is interesting to note that of the seven *Acanthococcus* species that occur on *Atriplex*, five are restricted to this host or are found on one other, probably incidental, genus and only two occur on four or more host genera. Of the species that occur on *Eriogonum*, only one *Acanthococcus* species is restricted

to *Eriogonum* and four occur on four or more host genera. For *Artemisia* there are two species restricted to this host and two that are polyphagous. For *Gutierrezia* and *Euphorbia* all four *Acanthococcus* species are polyphagous.

It appears that some interesting evolutionary trends have occurred in the *Acanthococcus* species that inhabit *Atriplex* and perhaps *Artemisia*. The relatively host-specific species that occur on these hosts are quite distinctive and are readily recognized even without a key. The significance of this phenomenon may become apparent when phylogenetic relationships among *Acanthococcus* species are analyzed.

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#### APPENDIX I

A Eulogy presented May 7, 1990 at the Memorial Service held at the Grace Presbyterian Church in Lanham, Maryland

Donald R. Whitehead was a unique character—I mean that as a double positive. He was a character among characters, for I am

told that systematic entomologists have a reputation for being somewhat unusual human beings. In the next several minutes I would like to describe why I characterize Donald as special and why he had an important influence on my life and career even during the last days of his life. Please forgive me if I take too long in this task, but this will be the last time that we will take the opportunity to think and talk about him for any extensive length of time. I think he deserves our thoughts.

Donald had a diverse combination of interests and personality traits and I certainly was not privy to them all. The words that describe him by my perception are: intellectual, unswerving, willpower, dedicated, researcher, insect identifier, curator, millipeds, stamp collector, computer, self deprecating, tropics, bowler, ground beetles, idea person, zoogeographer, seed weevils, weevils, West Virginia, Costa Rica, Mexico, quiet, bald, immigrant, colleague, friend.

Donald was first and foremost an intellectual, and, by my perception, he was quite bright. His more than 60 scientific papers reflect his probing interest in finding a pattern or explanation for generally accepted phenomena. For example, he was keenly interested in pests and later became especially curious about immigrant pests. He searched for characteristics that were shared by pest species of weevils so that he could predict which species were most likely to become pests in the future. He also investigated how to determine if a pest was an immigrant or naturally occurred in the U.S. Until Donald started asking these questions, I, at least, would never have considered questioning such basic terms as pest and immigrant. Donald could make almost anything an intellectual endeavor. At one point, he was asked to write a position paper on the mission of the Systematic Entomology Laboratory for presentation at a retreat. If I had been given this assignment, I would probably have copied an earlier mission statement, modified it to a limited extent, and been done with it. But not Donald! He

started completely fresh, talked with others in the Laboratory and produced so much interest that the mission generated more discussion than any other subject at the retreat. The point is that Don, by his questioning intellect, stimulated thought about a subject that was basic to the entire underpinnings of the Laboratory but never was given serious thought or consideration. He was an idea person.

His contributions were many and diverse and he had an unswerving dedication, even self-deprecating devotion, to the areas of his vocation. In research, he frequently became frustrated with his inability to find the perfect answer to a problem. He had very high expectations of himself, and, when he didn't achieve the unachievable, he would wait and gather more data rather than publish his already very significant contributions. He expected to develop a new theory of relativity, and, when he did not, he treated his findings as insignificant and unimportant. His colleagues tried to make him understand the importance of his discoveries, but because he expected more, he usually didn't accept our opinions. The research that he did publish is quite important, but I hate to think of the many discoveries that must be rediscovered in the future.

His research contributions and ideas were far from his only contributions at work. In 1985 he was given an award for outstanding achievement in providing insect identification services and information. If a U.S. port of entry, a homeowner, or a researcher required information and the name of a beetle of concern, Donald would spend hours or even days trying to find the answer. The information that he provided was always extensive and well researched and was far beyond what was expected. His curatorial contributions to the Smithsonian's National Insect Collection have been unheralded to now, but are deserving of special recognition. As Donald's supervisor, I have always been impressed during his yearly evaluation with the massive portions of the weevil collection that he had reorganized or

curated. Most scientists in the Laboratory have expressed their curatorial accomplishments in terms of drawers, while Donald only thought in terms of cabinets. With no assistance other than his own hands, he made large portions of the weevil collection available and usable for future research and scientific discovery.

For me, Donald had an important influence early in our relationship as a knowledgeable colleague, even teacher. I was a staunch believer in the old approach to systematics and was taught that cladistic approaches were useless. Donald, Chris Thompson, and I had lengthy, vigorous discussions about the subject. I can still remember Donald's animated gesticulations in his pursuit of making a point. What fun we had in learning from one another, even though to our wives it seemed that we were going to end up hating or even punching each other. It was during these sessions that Donald was given the nickname Baldhead. Several months after putting this label on him, I had second thoughts, since some are self-conscious about such attributes. I should have known better, since Donald seemed to pride himself in his polished dome and he often referred to himself as Baldy when he sent memos and mail messages.

This man had a willpower much stronger than most. For many years, Donald enjoyed the vices of smoking and drinking, but as time passed they became more and more of a problem. So as was typical of him, he simply decided to quit. Not only did he decide to quit both at the same time, against all advice, but he also decided to quit when it is most difficult—at Christmas and New Years—and of course, to tempt himself even more, by bringing a bottle of scotch whiskey as his contribution to the Christmas party downtown. As far as I know, Donald never wavered from his decision to quit. He never smoked or drank again.

Donald also was intense. When he decided to do something, he did it all the way even if the activity was recreational. At some point, he joined us in bowling duck pins one

evening a week. I don't think he even really wanted to bowl, but once he got started, he went at it with a vengeance. For most of us, bowling provided a change of pace one night each week. If we did well, that was fine, but if we didn't, it wasn't a concern. As often was the case, Donald wasn't satisfied with doing well. Each time he bowled he expected to do excellently; if he didn't he was upset with himself. In an attempt to overcome this problem, he decided to practice and I think he may have practiced as often as twice a week.

In the scientific arena, he had a broad array of interests from patterns of distribution as they translate to species recognition to revisionary studies of acorn weevils. He studied ground beetles, seed weevils, weevils, millipeds, parasitic wasps, true bugs and was very much enamored by the tropics, especially in Mexico and Costa Rica. He enjoyed doing field work and derived much pleasure from his work with George Ball, Dan Janzen, and John Kingsolver. The sounds, smells, and feel of the tropics had a special importance to Donald. But another area closer to home also was a favorite, namely West Virginia. The milliped fauna of West Virginia is especially diverse, and in the past several years he formulated a hypothesis of milliped mimicry in West Virginia. I thought it especially fitting that the presentation that I am giving here was written in his beloved West Virginia.

Even to his avocation, Donald brought an unusual amount of vigor and intensity. He was an expert on the post marks of Mexico during the period from 1870 to 1915 and made major contributions to a book on the subject. He also had special collections of post marks from Tasmania and recently started a West Virginia collection. When I asked him about his collection two weeks ago, he launched into a discussion that was well beyond his energy level. If he had been able, his arms would have been gesticulating as only Donald could make them, in his excitement over a subject that was dear to him. Up to the very end, he had Jo bidding on collections in mail auctions. During the early morning hours when Donald couldn't sleep because of chemotherapy treatment, he was working away on a database on Mexican post marks. He told me that it was of no value and not worth looking at, but I suspect otherwise.

In the end, Donald would not give up. He beat the odds for the last year of his life, a year that seemed especially important to him. In that year, he allowed himself some of the pleasures that his dedication would not allow previously. I am told that he purchased especially extravagant gifts for those he loved at Christmas. He allowed himself the time to visit with colleagues and he spent a lot of time in West Virginia studying millipeds.

I personally received a lot from old Baldy, and I will miss him greatly.